The So-Called Anterior Meningeal Artery: an Anatomic Study for Treatment Modalities

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Summary

The so called anterior meningeal artery (AMA) is a branch of the vertebral artery (VA), which had been interpreted as a supplying vessel of the dura in the foramen magnum and upper cervical level.

In this study, we examined the anatomy of this artery and relationships to its surrounding structures for treatment modalities. With the aid of magnification, five adult cadaveric head and neck complex and five cervical spines were examined after perfusion of the vessels with colored silicone.

The AMA arose from the VA between the C2 and C3 level, and passed medially through the intrervertebral foramen anterior to the dural sheath of the third cervical nerve root. It ran upwards dorsal to the deep layer of the posterior longitudinal ligament (PLL) with anterior internal vertebral venous plexus. Rostrally, it formed an arcade above the apex of the odontoid process with its contralateral mate.

The AMA gave off several tiny branches to the deep layer of the PLL, ligaments and soft tissues above the apex of the odontoid process, and vertebral bodies of the axis. At the level of the foramen magnum, it ended in several small twigs to the dura. Anastomoses between the AMA system and adjacent vessels were observed. One was directed through the hypoglossal canal to the ascending pharyngeal artery and the other was with the V3 segment of the VA. The origin and course of the two AMA, and anastomoses were symmetric. Although the AMA feeds the ventral dura of the foramen magnum, the perfusion area is larger than its name suggests, including the bony and ligamentous structures in the craniovertebral junction.

Anatomical knowledge of the AMA, including its anastomoses and layer relationships to the surrounding structures, may help to perform treatment modalities in this region rationally.

Introduction

The anterior meningeal artery (AMA), a branch of the vertebral artery (VA) was first identified by Greitz et Al in 1968, after discovery of the posterior meningeal artery, the first identified meningeal branch of the VA[1]. Its small size led to it being discovered only after the appearance of subtraction angiography. The artery was first described as arising from the main trunk of the VA immediately below its first bend at the level of the axis, and entering the spinal canal through the intravertebral foramen to perfuse the dura of the ventral aspect of the upper cervical spinal canal and foramen magnum [1]. Radiological studies have revealed it to feed lesions in the posterior fossa and craniovertebral junction [2-10]. Its anatomical characteristics, the subject of this study, have rarely been examined [11].

Material and Methods

Five adult cadaveric head-neck complex and five cervical spines were examined with 3 – 40X magnification following perfusion of the arteries and veins with colored silicone. Six of the specimens were dissected anteriorly, and four posteriorly.

Results

The AMA arose from the anteromedial surface of the VA between the transverse process of C2 and C3, and passed medially through the intravertebral foramen anterior to the dural sheath of the third cervical nerve root and its surrounding intravertebral veins (figure 1A,B).

The diameter of the origin at the VA, measured in six specimens of anterior approach, ranged from 0.80-1.20 mm (mean 1.00 mm) on the right side, and 0.60-1.02 mm (mean 0.82 mm) on the left side.

In the four specimens having a dominant right VA and in one specimen with no dominance of the VA, the diameter of the origin of right AMA was larger than the left side. One specimen with a dominant left VA had a larger origin on the left side.

In three specimens both arteries and an additional left artery arose just above the transverse process of the C3, and in both arteries and one right artery arose at the midpoint between the transverse process of C2 and C3. Distal to the origin it ascended slightly medially in the spinal canal, dorsal to the deep layer of the posterior longitudinal ligament (PLL), and the ventral surface of the anterior internal vertebral venous plexus [12] (figure 1B-E). Rostrally, it gradual tapered, and penetrated the tectorial membrane, the upper extent of the PLL, just above the upper margin of the horizontal part of the cruciform ligament (figure 2A). The AMA gave off several tiny branches to the deep layer of the PLL and vertebral bodies before penetrating the tectorial membrane. No branches reached the spinal dura in the cervical level (figure 2B). An arcade, the apical arch [13], was formed by the union of the paired arteries above the apex of the odontoid process. The apical arch was situated in the venous channels, and sent branches to the alar ligament, odontoid process, and soft tissue of the region (figure 2C,D). Branches arising from the apical arch or the segment below the entrance into tectorial membrane entered the hypoglossal canal and anastomosed with the ascending pharyngeal artery (hypoglossal ramus of the ascending pharyngeal artery or pharyngovertebral anastomosis) [13] (figure 3A,B). In two specimens in which the hypoglossal canal was divided into two parts by a bony septum, the anastomotic branch penetrated the lower canal. An anastomosis between the AMA and the anterior surface of the V3 segment of the VA was observed in two specimens bilaterally (figure 3C). The tiny branch of the AMA on the clivus, seen in three specimens, coursed between the dura and the attachment of the tectorial membrane to the clivus or on the clivus under the attachment of the tectorial membrane (figure 3C,D).

The origin, course of the two AMA, and anastomoses were almost symmetric.

Discussion

The AMAs on normal angiography are tiny, usually, less than 0.5 mm in diameter, with only its proximal 10 to 15 mm being seen [1,8].

Because of the low visibility in normal study, 19/40 (47.5%) - 24/50 (48%) [1,8], enlargement of this artery suggested existence of extraaxial posterior fossa lesions and rarely intraaxial posterior fossa lesions invading adjacent bony structure. This artery has been seen to feed glomus jugular tumor, meningioma, hemangioblastoma, metastatic tumor, plasmacytoma, chordoma, schwannoma of the vagus nerve, dural arteriovenous fistula, and traumatic arteriovenous fistula [2-10].

The territory of the AMA had been thought to be purely meningeal in early radiological reports [1,8], but later anatomic study showed that an artery, previously named the posterior ascending artery of the axis, was the AMA and that it along with the anterior ascending artery of the axis and perforators from the extracranial internal carotid artery, supplying the odontoid process [11]. Lasjaunias et Al stated those differently named meningeal and bony arteries were all the same [13]. They evaluated the embryology of the artery and found it to be a branch of the pedicle of the C3 somite, because the arterial pedicle of the occipital artery corresponds to the arterial pedicle of the C2 somite [14]. They stressed that the artery should be called the C3 branch of the cervical VA based on the theory of the ontogenesis and the territory that was not only meningeal but also included the axis. The present study also suggests that it is

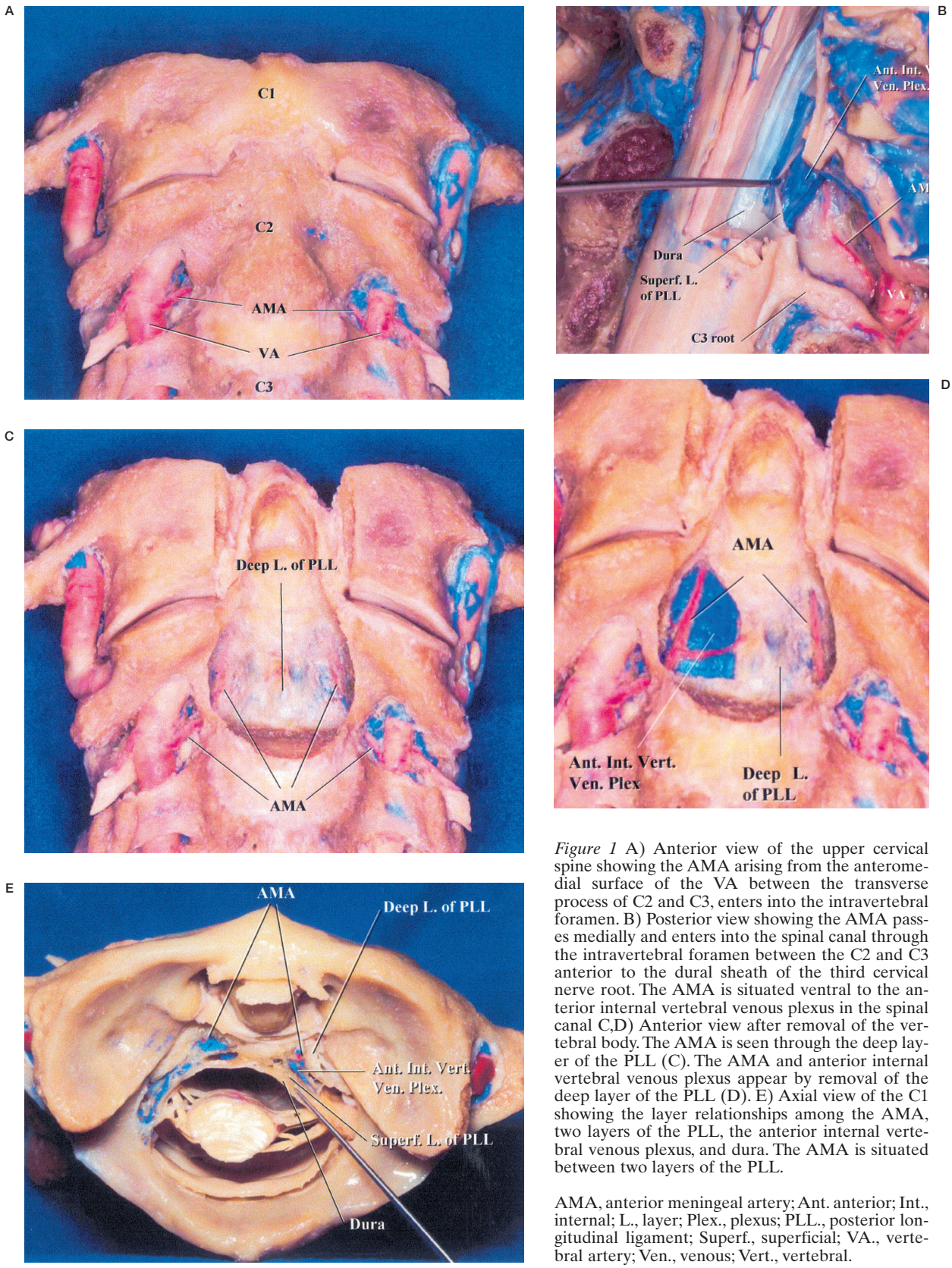


Figure 1 A) Anterior view of the upper cervical spine showing the AMA arising from the anteromedial surface of the VA between the transverse process of C2 and C3, enters into the intravertebral foramen. B) Posterior view showing the AMA passes medially and enters into the spinal canal through the intravertebral foramen between the C2 and C3 anterior to the dural sheath of the third cervical nerve root. The AMA is situated ventral to the anterior internal vertebral venous plexus in the spinal canal C,D) Anterior view after removal of the vertebral body. The AMA is seen through the deep layer of the PLL (C). The AMA and anterior internal vertebral venous plexus appear by removal of the deep layer of the PLL (D). E) Axial view of the C1 showing the layer relationships among the AMA, two layers of the PLL, the anterior internal vertebral venous plexus, and dura. The AMA is situated between two layers of the PLL.

AMA, anterior meningeal artery; Ant. anterior; Int., internal; L., layer; Plex., plexus; PLL., posterior longitudinal ligament; Superf., superficial; VA., vertebral artery; Ven., venous; Vert., vertebral.

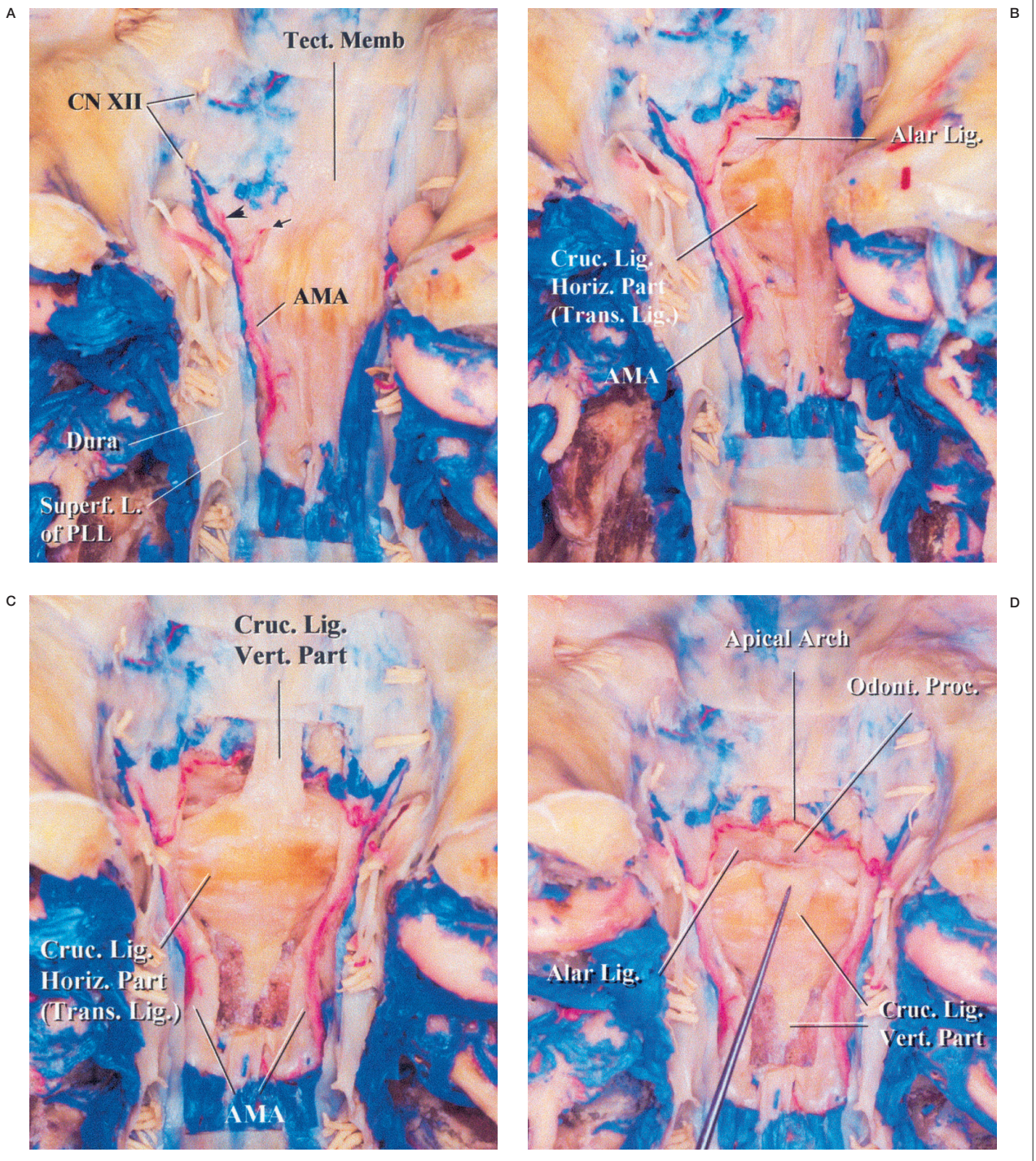
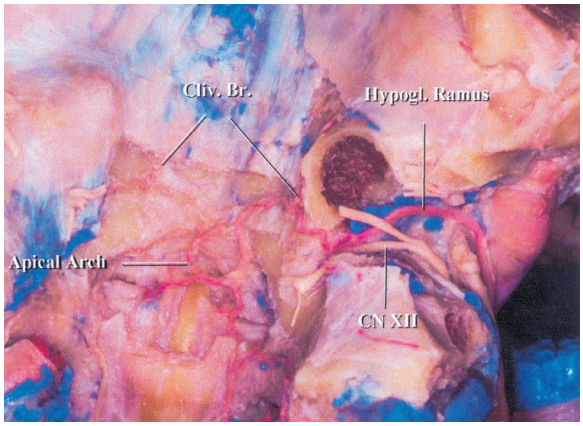


Figure 2 A) Posterior view after removal of the anterior internal vertebral venous plexus, showing the AMA penetrates the tectorial membrane, the upper extent of the PLL, just above the upper margin of the horizontal part of the cruciform ligament (arrow). Branches entering into the hypoglossal canal can be seen (arrowhead). B) Below the level of penetration of the tectorial membrane, the AMA gives off several tiny branches to the deep layer of the PLL and vertebral bodies, while no twigs reaches the spinal dura in the cervical level. C,D) Bilateral AMAs run anteromedially after penetration of the tectorial membrane (C), and form an arcade, apical arch, with its mate on the contralateral side above the apex of the odontoid process (D).

AMA, anterior meningeal artery; Br., branch; CN, cranial nerve; Cruc., cruciform; Horiz., horizontal; Hypogl., hypoglossal; L., layer; Lig., ligament; Memb., membrane; Occip., occipital; Odont., odontoid; PLL., posterior longitudinal ligament; Proc., process; Superf., superficial; Tect., tectorial; Trans., transverse; Vert. vertical.

A



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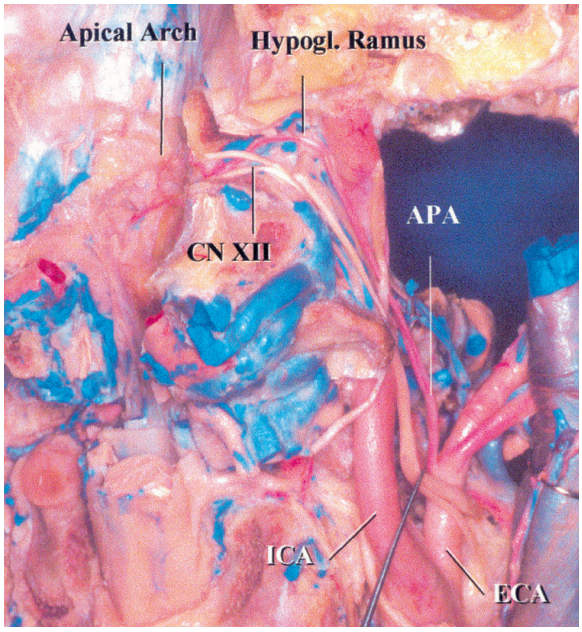
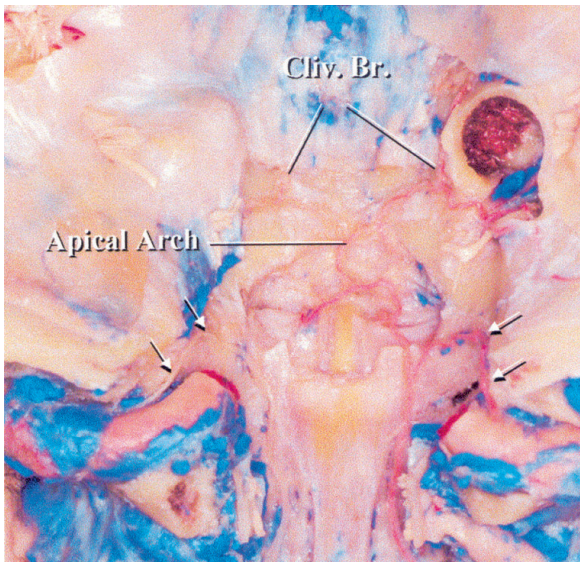


Figure 3 A,B) Branches of the AMA entering into the hypoglossal canal originated from the apical arch showing an anastomosis with hypoglossal branch of the ascending pharyngeal artery (pharyngovertebral anastomosis). C) An anastomosis connecting the AMA and the V3 segment of the VA is shown bilaterally (arrows). The AMA system connects with the tiny branches of the dura on the clivus. D) Anterior view after removal of the clivus, anterior arch of the C1, and odontoid process and body of C2, showing the branches of the AMA on the clivus.

AMA, anterior meningeal artery; APA, ascending pharyngeal artery; Br., branch; Cliv., clival; CN, cranial nerve; Cruc., cruciform; ECA, external carotid artery; Hypogl., hypoglossal; ICA, internal carotid artery; Lig., ligament.

C



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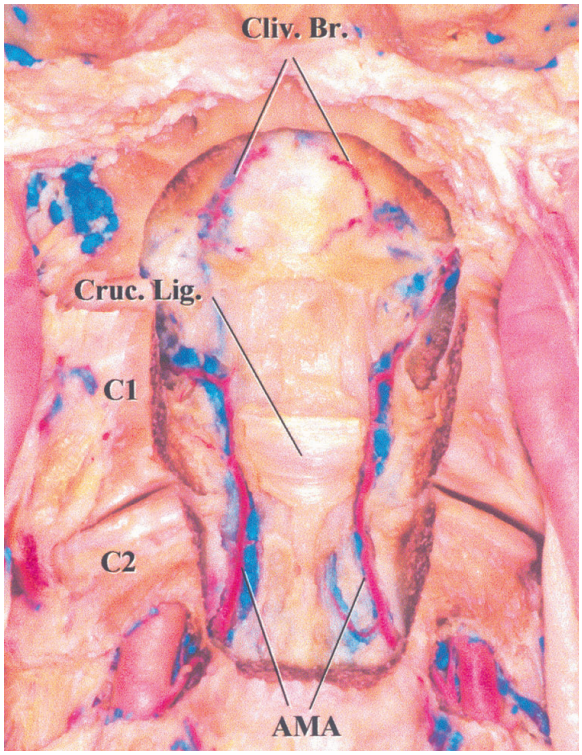

more than a meningeal artery, and its predominant supply is not to the dura, but to bony and ligamentous structures.

The artery has been previously described to course ventral to the internal vertebral venous plexus[1], or between the PLL and the dural sac[15]. However, our study revealed that the artery coursed just dorsal to the deep layer (ventral layer) of the PLL.

The artery has usually been described as supplying the dura in the upper cervical region[1,15], however, it is usually separated from this dura

by the anterior internal vertebral venous plexus being situated between two layers of the PLL. Therefore this artery may supply the dura if the venous plexus is absent by a neoplasm with dural attachment.

In intravascular embolization for the lesions fed by the AMA, the anastomosis with the ascending pharyngeal artery through the hypoglossal canal (pharyngovertebral anastomosis) has been reported to cause palsy of the lower cranial nerves [13]. This anastomosis and the anastomosis between the AMA and distal VA (V3) shown first in this study, should be recalled as dangerous anastomoses, as well as anastomoses between the other arteries supplying the dura mater around the foramen magnum; the dorsal meningeal branch of meningohypophyseal trunk arising from the intracavernous segment of the internal carotid artery, the branches of the middle meningeal artery, the posterior meningeal artery arising from the distal VA (V3), and the meningeal branches of the occipital artery [15,16].

The artery may be exposed in the transoral-transpharyngeal approach [17,18], transcervical approach [19], transcondylar approach [20], extreme-lateral approach [21], and extreme lateral-transatlas approach [22] to the craniovertebral junction. Knowledge of the AMA and its relationship to the venous plexus, ligaments, and bone will aid obtaining satisfactory results with the above approaches.

Conclusions

The anatomical relationships of the AMA to the adjacent structures were presented. The knowledge that the perfusion area of the AMA is larger than its name suggests, and that the artery forms anastomoses between the adjacent vital arteries, may help to shed light on the feeding vessels of pathologies in the craniovertebral junction, and perform both intravascular and direct surgery of this region rationally.

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EDITORIAL COMMENT

This article submitted to Interventional Neuroradiology for publication concerns the microsurgical anatomy of the anterior meningeal artery (AMA); the authors studied ten silicon injected cadaver specimens (six from anteriorly, four from posteriorly). This work is a good contribution to the AMA anatomical knowledge and the iconography is superb as usual from the Gainsville neuroanatomy laboratory.

In the introduction, the word radiologically should be added because the AMA was described previously in the nineteenth century by anatomists; on the other hand, Greitz was the first radiologist to identify the AMA using subtraction angiography.

Sacrifice or preservation of the AMA during the surgical procedure, in my experience, have no consequences because of the anastomoses; on the contrary, these anastomoses can be very dangerous if an intravascular embolization is needed.

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